# EXTERNAL MORPHOLOGY OF THE COLORADO POTATO BEETLE (LEPTINOTARSA DECEMLINEATA SAY)[1]

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## INTRODUCTION

From an economic standpoint, the Chrysomelidæ, or leaf-beetles, constitute one of the most important groups of beetles, while from the size and great diversity of types included, the family has become of the very greatest interest and importance to the taxonomic student. A considerable amount of work has been accomplished toward the identification and classification of these forms but much remains to be done. Perhaps because of the general small size of the included members, the morphology of the Chrysomelidæ has been sadly neglected. The present writer strongly feels that there should be more coöperation between the taxonomist and morphologist, thus minimizing the misinterpretations of body-parts and the consequent confusion of terms in use. The purpose of the present discussion is to present a detailed morphological description, not only of the external features, but of the internal genitalia as well.

General works on the morphology of various groups of Coleoptera in American literature include the following: The external morphology of *Phyllophaga,* one of the Scarabæidæ, by Hayes (1922), with a somewhat similar treatment of the Elateridæ by Van Zwaluwenberg (1922). More recently certain important works treating of the Coleoptera in general have been published: The head-capsule by Stickney (1923); the wing-venation and methods of folding by Forbes (1926), Graham (1922) and others; and the female genitalia by Tanner (1927). As a result of these various works, certain new interpretations in parts have been proposed, and a correlated discussion such as the present work attempts seems to be greatly needed.

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For the purposes of the present study, the Colorado potato beetle was chosen because of its size, being one of the largest chrysomelids in this country, and because of its wide distribution and economic importance. Of all the Chrysomelidæ this is one of the most common pests, being found over the entire United States, in Canada, Mexico, Central America, and, in recent years, it has been carried to Europe, where it is now apparently permanently established.

The insects collected were preserved in 70 per cent. alcohol, and when needed for dissection were washed in water and boiled in a 10 per cent. solution of potassium hydroxide to remove soft tissues. Additional specimens with the soft tissues retained were also examined. A Zeiss binocular microscope was used in all dissections, and a strong light was furnished by a Spencer high power Mazda microscope lamp (400 wt., 100 volt).

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## General Description

The Colorado potato beetle, *Leptinotarsa decemlineata* Say, belongs to the subfamily Chrysomelinæ, differentiated from other chrysomelids in having the head inserted in the thorax to the eyes, antennæ widely separated at base, and the front coxæ transverse. The genus *Leptinotarsa* to which it belongs is characterized by having the tarsal claws simple, third joint slightly emarginate, pronotum margined at base, and mesosternum not raised above the level of the prosternum. The adult beetle is oval, robust and convexly round. The total length ranges from 6–11 mm. The ground color of the beetle is dull yellow. The following areas are black or blackish: a "heart" shaped spot on vertex, entire occiput, posterior parts of genæ and gula, the margins of the pronotum, two short divergent lines on pronotal disk with six small spots on either side. The size and number of these spots vary in different individuals. The margins of the three sterna, coxæ, genicula of legs, and tarsi are also black.

Oblong spots are found on each pseudo-pleuron, and four on each ventral segment. Each elytron has the sutural margin with five lines black, the second and third unite at apex. Tip of antenna is piceous-black.

## THE HEAD

HEAD CAPSULE (Figs. 1 and 3). The head capsule of *L. decemlineata* Say is composed of several sclerites, many of which have fused entirely, so that in this species certain sutures present in other insects, or even in other Coleoptera, have disappeared. When we examine the head of a potato beetle from its dorsal surface (Fig. 1) we note the epicranial suture (*es*) (see Stickney, 1923), branching at its anterior end into a left and right arm (*esa*). The epicranial stem of this suture (*es*) is faint, especially at its posterior end; the epicranial arms, however (*esa*), are more distinct, directed laterad and later curve latero-cephalad. The punctured area (KF) between the epicranial arms is a fusion of the frons (F) and clypeus (K) and has been termed *clypeo-frons.* For demarcation between frons and clypeus we may draw an imaginary line between the two frontal pits (FP) near the ends of the epicranial arms. These pits are the external manifestation of internal invaginations that form the anterior processes of the tentorium to be discussed later, and in most cases serve as such demarcations. On each side of the clypeus is a minute sclerite, the clypealia (*k,* Figs. 4 and 5) (paraclypeus of certain authors). Each of these sclerites is quadrangular and fits into a socket of the mandible, furnishing thus a point of articulation for the latter. The membraneous anteclypeus (AK) is the anterior part to the clypeus and is connected to the labrum (LR).

On both sides of the epicranial stem are found the punctured sclerites of the vertex (V). The punctured occiput (O) is posterior to the vertex, and the genæ are situated laterally. The ventral surfaces of the genæ (GE) bear small punctures in which are minute setæ. In the cephalo-ventral end of each gena there is a cavity known as the acetabulum of the gena (AC, Fig. 4); this acetabulum receives the condyle of the mandible and furnishes thus a second point of articulation for the latter. There is a ridge near the acetabulum which, together with the ridge traversing the submentum, form a demarcation between mouthparts and head capsule (Fig. 3). The smooth area marked *g*, Fig. 3, is the gula. Its anterior demarcation is the gular-mental suture (*gms*) and from the genæ it is demarked by the gular sutures (*gs*) on both sides; the curvature of these latter give the gula a bell-shaped appearance. The cavity (FM) caudad to the gula is the foramen magnum, or occipital foramen. Through this opening the alimentary canal, blood vessels and nerve cord, etc., pass from the head to the body.

ENDOSKELETON (Figs. 3 and 6). The posterior parts of the gular sutures are known as the gular pits (*gp*). These are the external manifesatation of the internal processes that are visible as two lobes through the foramen magnum. These lobes are the posterior arms of the tentorium (*p*T), and they are continuous with the apodems along the gular sutures. Projections of this membrane connect each of these lobes with the respective anterior arm of the tentorium (*a*T); a thin membrane (*b*T) also connects the two lobes to each other, and that may represent the body of the tentorium. This entire structure serves for strengthening the head capsule and for muscle attachment.

EYES. The eyes (E) are very prominent organs in the head. They are oblong and about three times longer than wide.

ANTENNÆ (Fig. 2). Near the end of each epicranial arm is the antennal socket (*as*), Fig. 4. This cavity receives the bulb, the basal part of the first antennal segment, and is supported by the antennifer (AF). The first segment of the antenna is called scape, and, as in all insects, it is the longest of the segments. The second segment is called the pedicel and is the shortest of all. The five first segments are glabrous and bear single setæ, the six other segments, especially those at the apex, are broader and more pubescent. The seventh segment has a tooth-shaped projection at the side of its apex.

LABRUM (Fig. 9). The labrum is hinged to the membraneous anteclypeus. It is quadrangular with the anterior margin rounded and posterior angles the tormæ—projecting caudad. The external surface of the labrum bears setiferous punctures;

the internal surface is membraneous and is a continuation of the external cuticula. It extends caudad, and forms a roof to the pharynx; hence it is termed epipharynx. The anterior margin is covered with sensory setæ, and a group of gustatory spinules is found a little caudad of the anterior margin. The epipharynx is connected at its lateral margins to two rods of chitin (*d*) which are united at their anterior end to the tormæ of the labrum; at their distal third they bend dorso-mesad so that their distal ends approach each other. A strong muscle attaches these ends to the dorsal region of the head. The entire pharynx and part of the œsophagus are suspended upon this structure. The phylogenetic origin of these rods is not clear. They are found in the cerambycid beetles, as *Tetraopes tetraophthalmus,* and in other chrysomelids, *Chrysochus auratus* and *Chelymorpha cassidea.* They are soft and partly membraneous in certain scarabæids, and are obsolete in Cantharoidea. It is probable that the rods in question arose by chitinization of the lateral margins of the epipharynx.

Mandibles (Figs. 4, 5, 7 and 8). The mandibles are found on both sides of the labrum and are partly covered by it. In the chrysomelid beetles in general they serve for cutting leaves rather than for grinding, hence are sharp and their margins, the incisors, overlap each other like a pair of scissors. They articulate with the head capsule at two points; a dorso-lateral point where the clypealia fit into the socket of each mandible (Fig. 4), and the ventro-lateral point where the globular swelling of each mandible, the condyle (*Q*) fits into the acetabulum of each gena. The mandibles are opened when the adductor muscles contract. These are attached at meso-ventral side of each mandible. The adductor muscles are the larger, and are attached to tendons. The edge of each mandible is provided with three denticles, the one continuous with the ventral margin, the so-called distal denticle; a second one dorsad to the distal denticle; and a smaller one at the middle of the dorsal margin. At the proximal end of the dorsal margin is situated the submola (*SMo*). This is a submembraneous lobe and lies under the labrum. The spinules upon it are probably sensory organs, as are probably the setiferous punctures upon the external surface of the mandibles. The molar region (*Mo*) is smooth and not well developed as in other beetles.

MAXILLÆ (Fig. 10). The maxillæ are situated ventrad of the mandibles and consist of the following parts: the cardo, stipes, palpifer, palpus, subgalea, lacinia, and galea. The cardo (*Ca*) is the sclerite which articulates with the gena, the point of articulation being the groove marked *CaG*. The cardo process (*CaP*) projects laterad into the head capsule, and to it is attached the muscle that opens the maxilla. The sclerite attached to the cardo is usually regarded as the stipes, though it is probably only a basal sclerite of the stipes. The margins of this sclerite are folded dorsad and are united with each other by membrane. The palpifer (PF), a cylinder of chitin, is attached to stipes and bears the four-segmented palpus (MXP). The so-called subgalea (*SGa*) is also connected with the stipes and bears the two-segmented galea (*Ga*) and the broad semi-membraneous lacinia (*La*). The palpus, galea and lacinia are all covered with sensory spinules, probably organs of touch, smell and taste.

LABIUM (Fig. 11). The labium or the under lip is attached to the head capsule at its ventral wall between the two maxillæ. The gula (*g*) unites with the submentum (*bm*), a sclerite which is heavily chitinized and is traversed by a ridge. At the lateral ends of the submentum are two chitinized rods which project dorso-laterad into the head capsule, and unite firmly with the genæ, thus bracing the entire labium. The lateral margins of the mentum (*m*), which is attached to the submentum, are bent dorsad and are connected with the membranous hypo-pharynx (*HX*). The prementum (*pm*) is the membrane connecting the mentum with the so-called ligula (LG), which is composed of the two paraglossæ (*pgl*) and the median glossa, a rudimentary single piece, embedded between the paraglossæ. The palpiger (PG) on both sides of the paraglossæ bear the three-segmented labial palpi (LIP). The anterior margins of paraglossæ merge into the membraneous tongue-shaped hypopharynx (*HX*) which forms the floor of the mouth. A curved rod is embedded in the ventral part of the hypopharynx, this rod in turn is connected with the glossa, and thus strengthens the hypopharynx. Very minute spinules which are probably gustatory organs are scattered all over the hypopharynx. The three segmented palpi born by each palpiger bear setæ, which also are probably sensory.

## THE THORAX

PROTHORAX. The pronotum (Figs. 12 and 14) is convex, about one and one-half times as broad as long. The sides at the anterior end curve mesad, so that the base of this sclerite is broader than its apex. The pronotum does not end with the lateral carina, but extends further to the ventral surface where its margins overlap the pleura and fuse with them (See Crampton, 1926). The area SN along the ventral side of the lateral carina is the *subnotum.* The triangular area *q* is the ventral part of the pronotum and has been termed pseudo-pleurum; this part apparently has fused with the pleurum on each side. The prosternum (Fig. 14) is comparatively small. The median part (*bs*) is the basisternum, and the lobe (L) between the coxæ is the prosternal lobe. The two arms (*px*) extending from the basisternum laterad and uniting with the pseudopleura are the *precoxales.* Upon removing the coxa from the coxal cavities, the concave areas of the furcasternum (*fcs*) are exposed. The posterior margins of these areas are more chitinized than in the center. In some Chrysomelids this chitinization is complete, so that the margin reaches the same level of the pseudopleuron and prosternal lobe; then the coxal cavities are called closed; otherwise they are called open. The *furcal pits* (*fcp*) are the external manifestation of the invagination forming the *furcæ* (*fc*).

PROTHORACIC LEG (Fig. 13). At the anterior lateral angle of the coxal cavity cc lies the *trochantin* (*tr*), a small curved sclerite attached to the internal muscles of the prothorax. The acetabulum of this sclerite receives the condyle of the coxa. The coxa, C, one and one-half times as long as wide, rotates in the coxal cavity antero-posteriorly. At the apex of the coxa there is a cavity which receives the condyle of the trochanter (TR). This is a small sclerite and its articulation with the coxa is sidewise across the body and being firmly attached to the femur (F) it swings the entire leg in those directions. The *femur* is more than twice as long as wide. The proximal end is more slender than the apex, where a cavity receives the condyle of the tibia (T). A notch at the ventral margin of the apex of the femur gives the tibia considerable freedom in is articulation so that the latter can describe a circle of about 120°. The tibia is a little longer than the femur, but more slender, especially at its proximal end. The apical end is hairy and its margin is armed with a row of minute spinules. The socket at this end receives the condyle of the first tarsal segment. The margin of this socket is notched dorsally, to give the tarsus freedom in movement. In the tarsus (TA) the fourth segment is much reduced and firmly united with the fifth, so that the tarsus appears as four-segmented. (This type of tarsus is characteristic of all Cerambycoid beetles and also of Rhynchophora, where the fourth and fifth segments fuse.) Of the basal three tarsal segments, the second is the smallest. The three are pubescent beneath, broad and emarginate at the apical edge. The last segment is glabrous, slender, longer than the others, and bears two large simple claws.

MESOTHORAX (Figs. 15 and 16). Of the three thoracic segments, the mesothorax is the smallest. In the mesonotum (Fig. 15) we distinguish three distinct areas: the prescutum, $psc_2$, scutum $sc_2$ and scutellum $sl_2$. The prescutum ($psc_2$) is a heavily chitinized area with two antero-lateral pointed projections, the anterior notal wing processes (*AWP*), and two blunt lateral tubercles, the posterior notal wing processes (*PWP*). Both processes on either side are connected by means of membrane to the process of the elytron as shown on the right-hand side in Fig. 15. The scutum ($sc_2$) is the depressed area posterior to the prescutum on both sides of scutellum ($sl_2$). The two grooves on both sides receive the anterior projecting margins of the elytra which are held thus in place during rest. The scutellum, the triangular elevated area $sl_2$, is the only exposed part of the mesonotum and its margins overlap the anterior mesal angles of the elytra during rest.

The mesopleurum (Figs. 16, 19 and 20) is represented by two sclerites, the episternum ($et_2$) and epimerum ($er_2$). The pleural suture (Ps) which is the external manifestation of the internal pleural ridge (PR) serves as demarcation between the two sclerites. The anterior dorsal process of the episternum is known as the ventral wing process (*VWP*). It supports the process of the elytron and is attached to it by membrane and tendons. The ventral margin of the episternum is connected with the mesosternum and touches the trochantin. A hairy diagonal ridge divides the episternum into two areas, the dorsal-anterior one being small and smooth, and the ventral one larger with roughened surface. The epimeron ($er_2$) is connected only at its anterior margin with the episternum, the other sides being free, for under this sclerite is hidden the second thoracic spiracle and a free passage of air is necessary. The pleural ridge (Pr) is broad and tapers ventrally and reaches the furca. These processes both furnish points of attachment for the thoracic muscles. The pentagonal area *bs,* Fig. 16, is the basisternum, while the areas in front of the coxal cavities are the precoxales of the mesosternum. The front part of the precoxales rest on the coxæ of the prothorax and therefore are concave and smooth. Upon removing the coxæ the furcasternum (*fcs*) is exposed with the furcal pits (*fcp*) at the lateral margins. The areas of the furcasternum are closely connected with the inflexed region of the metasternum. The sutures between the furcasternum and inflexions of the metasternum are the external manifestation of an internal projection which forms a connecting bar (*ba,* Fig. 20) between the two coxal cavities (Fig. 20). The mesothoracic legs are much like those of the prothorax, except that they are very slightly larger.

Elytra. Each elytron is triangular and convex, when viewed from above. The anterior margin tapers downward abruptly into the apophysis (ap, Fig. 15). The two other sides of each elytron taper gradually into a point. The two elytra taken together cover most of the mesothorax, metathorax and abdomen, and give the insect a hemispherical appearance. There are eleven punctured striae in each elytron. The sutural margin of each elytron, and also the five alternating intervals, are black, while the epipleurum is pale. The apophysis of the elytron is well connected to the first axillary plate, and to the anterior wing process of mesonotum. The second axillary plate which is embedded in the alary membrane links the apophysis with the wing process of the mesoepisternum. The third axillary plate connects the apophysis to the posterior notal wing process. The axillaries are well interlocked with the apophysis, flexible, vary in shape and their position only is shown in Figure 19.

During rest the elytra are kept in position by means of the following devices:

1. By fitting the swollen median margin of the elytra into the median groove (G, Fig. 15), on the metanotum.

2. By slipping the anterior median angles of the elytra under the mesoscutellum ($sl_2$).

3. By slipping anterior margin into the lateral grooves of the metascutum.

4. By coadaptation of lateral margin of the elytra to the ridges of the metaepisternum.

METATHORAX (Fig. 15). The metathorax is the largest of the three thoracic segments in accord with the larger metathoracic wing muscles. In the metanotum there are four distinct areas: prescutum, $psc_3$, scutum, $sc_3$, scutellum, $sl_3$, and postscutellum, $psl_3$. The prescutum ($psc_3$) is a narrow arched sclerite just beneath the mesoscutellum. At the anterior margin it is connected by means of membrane to the mesothorax; the posterior margin merges into soft chitin connecting it with the scutum. The prescutum at the middle is narrow, becoming wider laterally. The lateral margins (MK) are termed the muscle disks; they are more chitinized, blunt, and fuse with the scutum ($sc_3$). A depression on either side demarks the muscle disks from the mesal portion of the prescutum.

The scutum, $sc_3$, largest of the metanotal areas, is divided longitudinally by the median groove (G); this latter receives the thickened mesal margins of the elytra during rest, holding them in position. Each of these portions is further divided by a long curved furrow, this being the external manifestation of internal invagination for muscle attachments. At the lateral ends of the scutum are the anterior notal wing processes (*AWP*) and the posterior notal wing processes (*PWP*). The scutellum is the third area marked $sl_3$. The median groove (G) likewise divides this into right and left divisions. The scutellum becomes very narrow as it spreads laterad, and is closely connected with the posterior wing process of the scutum. The postscutellum is the narrow sclerite ($psl_3$). In the middle it is very narrow, and the lateral ends of it are closely connected with the metaepimerum, Figs. 18, 22.

The metapleuron (Fig. 18) consists of the metepisternum and the metepimeron. The diagonal pleural suture (Ps) demarks the two sclerites. The metepisternum is prolonged dorsally into the ventral wing process (*VWP*) ; the smooth region (MK), below the process is a muscle disk. The metepimeron is partly membranous, and heavier chitinization occurs along the pleural suture. The membrane in the middle merges with the alar membrane.

The metasternum is the large sclerite (ST, Fig. 16). A longitudinal suture divides it into left and right sections. The anterior inflexion forms part of the coxal cavities of the metathorax and merges with the furcasterna. The posterior inflexion (*pi*) projects literally and merges into two strips of soft chitin and membrane which surround the metacoxæ.

The metathoracis leg differs from the other legs in the following respects: there is no trochantin; the rotation of the coxa is more restricted; the entire dorsal surface of the latter is membranous; the femur is a little thicker than the other femura and the entire leg is a little larger than the other legs.

WING ARTICULATION. The wing is connected to the body by means of the alar membrane. This membrane is strengthened by small curved sclerites called axillaries. The costa of the wing articulates with the ventral wing process of the episternum. The base of the subcosta forks into dorsal and ventral projections. The dorsal projection articulates with the first axillary (*1X*) which is supported by the anterior wing process, and the ventral projection is supported by the ventral wing process of the metepimeron. The radius is articulated with the second axillary (*2X*) which is below closely connected to the first axillary. The cubitus and perhaps the base of median are supported by the third axillary (*3X*) while the anal region is connected to the fourth axillary (*4X*). When the wing is to be folded during rest, the fourth axillary rotates mesad, its middle angle resting on the plate ($x$), until the anterior end of this axillary is in the fold between the notal wing process and the first axillary. The connection with the wing is such that the entire anal region of the wing is drawn over the abdomen and the rest of the wing folded over it along the line CD, Fig. 17.

WING FOLDING. In figure 17, the dotted lines represent convex folds, while the full lines show concave folds. By the use of this figure, it is not difficult to explain this folding. The anal area folds under the wing along the convex fold (CD), and the apical part of the wing also folds along the line (AB). At the same time, however, the concave fold (QP) causes the two areas OPX and QPY to approach and lie upon one another. The secondary radial folding along OR, OS and OT causes the fold OX to lie upon OY; in their new position the folds OX and OY are under the wing along the line o-xy. At the same time a secondary folding along o-xy brings the tip of the wing under WVQ. It should be noted that the folding has had much to do with the reduction and modification of the venation. If the two figures 17 and 21 are compared, it will be noted that the main foldings are along veins, thus the fold AB is partly along radial branches and partly along M, where as QOT is along M, and branches of R, and the fold CD along 3A and 2A.

VENATION. In recent years different authors have made a study of the wing venation of Coleopetra, but there is lack of agreement as to the interpretation of the various veins. Since Forbes has made a more detailed comparison with other insects, his interpretation has been followed in the present paper.

The main feature characteristic of the wings of Coleoptera is that the main veins C, Sc, R, and M are crowded to the costal margin, Cu and the anal veins occupy the remainder of the wing. As shown by figure 21, C and Sc with R fuse together to form the pterostigmatic area at the middle of costal margin. R runs to about the middle of the wing and ends blindly; its branches occupy the area RRR and none of them reach the apex of the wing.

Tillyard interprets the vein labeled CuM as Cu; and d'Orchymont believes that the vein labeled $M_1$ is really $M_{1+2}$, and that the vein labeled $CuM_4$ is really $M_{3+4}$. Graham interprets the vein labeled $M_1$ as $R_5 + M_1$. The slender vein M is interpreted by Forbes, Tillyard and others as being the Median, its basal part is obsolete and therefore it is called the recurrent vein. Between the recurrent vein and Cu there is an open cell called the apterum, and this is characteristic of all phytophagous beetles. The Adephaga have a closed oblong cell called the oblongum. The veins posterior to Cu are the anals.

## THE ABDOMEN

Not all the abdominal segments present in other Coleoptera are found in the Colorado potato beetle. Modifications in structure have taken place, especially in the last abdominal segments. The first two tergites (1T and 2T) have no corresponding pleurites or sternites. The segments beyond the seventh are obscure and their shape and number differ in the male and female, to be discussed later.

TERGITES. The first six tergites, being covered and protected by the elytra, are soft and thinly chitinized; the seventh tergite, being exposed, especially in gravid females, is more chitinized and is termed the *pygidium*. Membranes connect the tergites with each other. These membranous areas are continuous with the membrane of the pleural region and that merges with the membrane of the metepimeron and with the pleurites. The first tergite is the narrowest of the seven, the second and third are the broadest, and the others are subequal. The membrane of the pleural region bears the abdominal spiracles.

SPIRACLES. There are two pairs of spiracles in the thorax, and seven pairs are visible in the abdomen. The first thoracic spiracles are situated in the membrane connecting the prothorax and mesothorax (Fig. 14, *Sp*). The second thoracic spiracles are in the membrane under the mesoepimeron. The first abdominal spiracles are behind the metapostscutellum (Fig. 22, 1 *Sp*). The other abdominal spiracles are situated in the lateral membrane connecting the tergites and pleurites, one pair corresponding to each of the first seven tergites. According to Tanner there should be one more pair near the eighth tergite.

PLEURITES. The five pairs of pleurites (3P to 7P) correspond to the five last visible tergites. The first of these pleurites (3P) is large and is continuous with the membrane of the metepimeron; parts of it are more chitinized than the others. The other pleurites are smaller, and their dorsal margin is thin and merges into pleural membrane.

STERNITES. There are only five visible sternites; the first two have either fused with the third or else disappeared. The sternites are much more chitinized than the pleurites and tergites, and are pigmented after a definite pattern. The inflexed margins of the sternite (3s) form the posterior portion of the coxal cavity of the metasternum.

TERMINAL ABDOMINAL SEGMENTS. ♀ (Figs. 25 and 28). The posterior margin of the seventh tergite bends and folds internally and is connected by membrane with a plate of chitin (8T) which is very thin, especially along the median area. This plate is the eighth tergite (See Tanner, 1927). Its posterior margin is bent and folded also, and merges with the dorsal wall of the rectum (RM). Between the anus (AN) and vagina (VA) there are two plates (XT) interpreted as the coxite and styli (*Sl*) of the ninth segment. The sclerites (*v*) near the coxites are the valvifers. The plate (8s) at the ventral margin of the vagina opening is the eighth sternite, which is connected by membrane with the inwardly folded posterior margin of the seventh sternite. Near the opening of the oviduct into the vagina there is the opening of the recepticulum seminis (*SR*); the tips of the seventh sternite and tergite as well as the styli bear sensory setæ.

TERMINAL ABDOMINAL SEGMENT. ♂ (Figs. 23–24). The posterior margin of the seventh tergite (7T) folds internally and is connected by membrane with the eighth tergite (8T). The connecting membrane is quite broad and enables the eighth tergite to be protruded during copulation. The posterior margin of the eighth tergite bends inwardly and is connected with the rectal membrane, forming the dorsal margin of the anus. The ventral part of the anus is muscular and two chitinous plates (Figs. 23, 26) support this fleshy lobe laterally. The ventral part of this lobe is continuous with a transparent membranous tube surrounding the copulatory organ; the opening of the transparent tube is connected ventrally with the inwardly bent seventh sternite. The posterior margin of the tube is connected with the rounded v-shaped tegmen (Figs. 23, 26, *Tg*) (See Charp and Muir, 1912). The tegmen surrounds the median lobe (*ML*), which is chitinized, curved and pointed. Some authors call this organ the flagellum or penis. The median lobe is composed of two lateral halves, and the place of fusion of the two is still thinly chitinized. Two rods of chitin (*d* Figs. 23, 26) are connected to the posterior margin of the transparent tube. These are fused at the other end, and lie below the median lobe.

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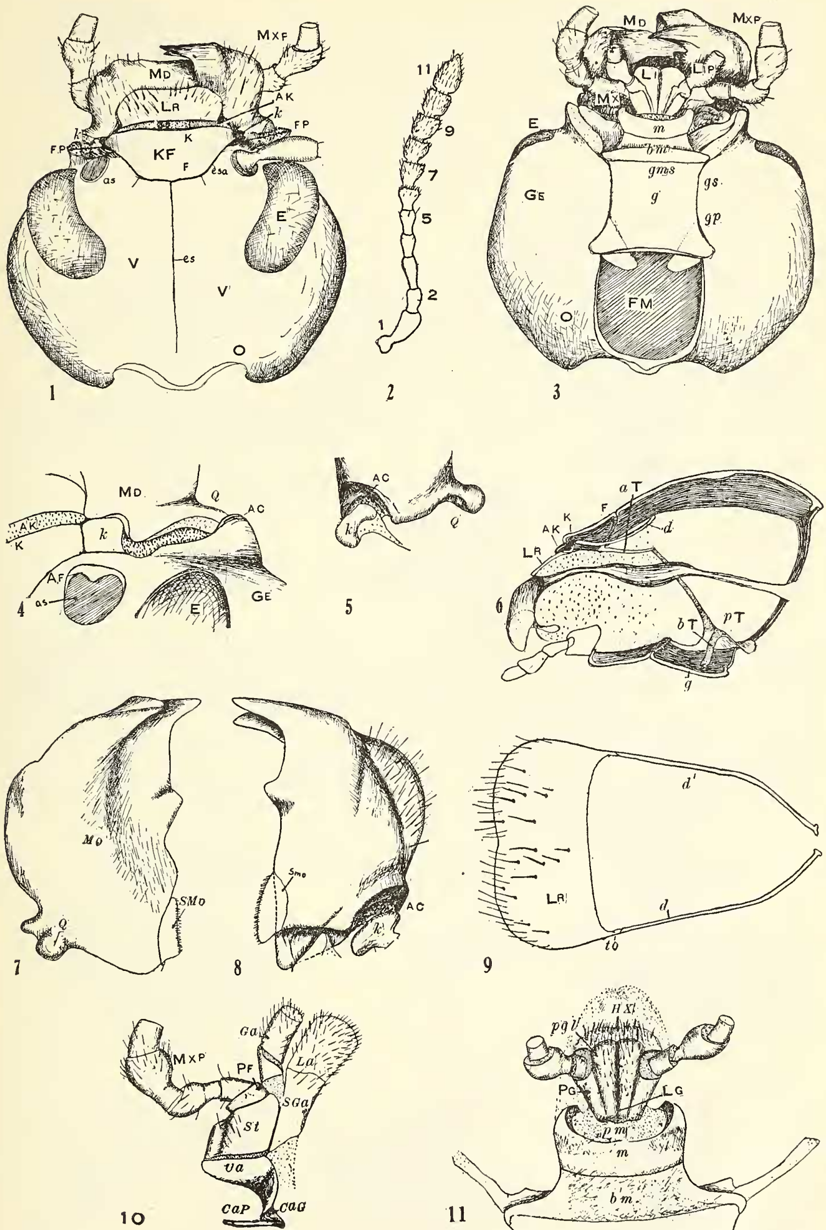
ABBREVIATIONS ON PLATES

A, Anal vein.
AC, Acetabulum.
AF, Antennifer.
AK, Anteclypeus.
AN, Anus.
AP, Apophysis.
*as*, Antennal socket.
*a*T, Anterior process of tentorium.
*AWP*, Anterior wing process.
*ba*, Internal process of mesofurcasternum.
*bm*, Submentum.
*bs*, Basisternum.
*b*T, Base of tentorium.
C, (In Fig. 21) Costa.
C, Coxa.
*Ca*, Cardo.
*CaG*, Cardinal groove.
*CaP*, Cardinal process.
Cu, Cubitus.
*d*, Rod of chitin.
E, Eye.
EL, Elytron.
*er*, Epimeron.
*et*, Episternum.
*F*, Femur.
F, Frons.
*fc*, Furca.
*fcp*, Furcal pits.
*fcs*, Furcasterna.
*Fl*, Flagellum.
FP, Frontal pits.
G, Metanotal groove.
*g*, Gula.
*Ga*, Galea.
GE, Gena.
*gms*, Gula mentum-suture.
*gp*, Gular pits.
*gs*, Gular suture.
*HX*, Hypopharynx.
K, Clypeus.
k, Clypeala.
KF, Clypeofrons.
L, Prosternal lobe.
LG, Ligula.
LI, Labium.
LIP, Labial palpus.
LR, Labrum.
M, Median vein.
*m*. Mentum.
MD, Mandible.
MK, Muscle disk.
*ML*, Median lobe.
*Mo*, Molla.
MX, Maxilla.
MXP, Maxillary palpus.
O, Occiput.
*Od*, Oviduct.
P, Pleurite.
*pi*, Posterior inflection of metasternum.
PR, Pleural ridge.
PS, Pleural suture.
*psc*, Prescutum.
*psl*, Post scutellum.
*p*T, Posterior process of tentorium.
*PWP*, Posterior wing process.
*px*, Precoxales.
*Q*, Condyle.
*q*, Pseudonotum.

R, Radius.
RM, Rectum.
S, Sternite.
SC, Subcosta.
*sc*, Scutum.
*sl*, Scutellum, Fig. 25 and 28 style.
*SMo*, Submola.
SN, Subnotum.
*Sp*, Spiracle.
*SR*, Seminal recepticulum.
ST, Sternum.
*St*, Stipes.
T, Tibia.
T, Tergite.
TA, Tarsus.
*Tg*, Tegmen.
TR, Trochanter.
*tr*, Trochantine.
*v*, Vertex.
V, Valvifer.
VA, Vagina.
*VWP*, Ventral wing process.
*X*, Axillary plates.
x, Small axillary plate.
XT, Coxite.

## PLATE VI

Figure 1. Head—(dorsal view).
Figure 2. Antenna.
Figure 3. Head—(ventral view).
Figure 4. Base of mandible, showing attachment to head capsule.
Figure 5. Base of mandible detached, showing condyle and acetabulum.
Figure 6. Cross-section of head, showing interior structures.
Figure 7. Mandible (right one), ventral surface.
Figure 8. Mandible (right one), dorsal surface.
Figure 9. Labrum (dorsal surface), showing the chitin rods.
Figure 10. Maxilla (right one) ventral (exterior) surface.
Figure 11. Labium.

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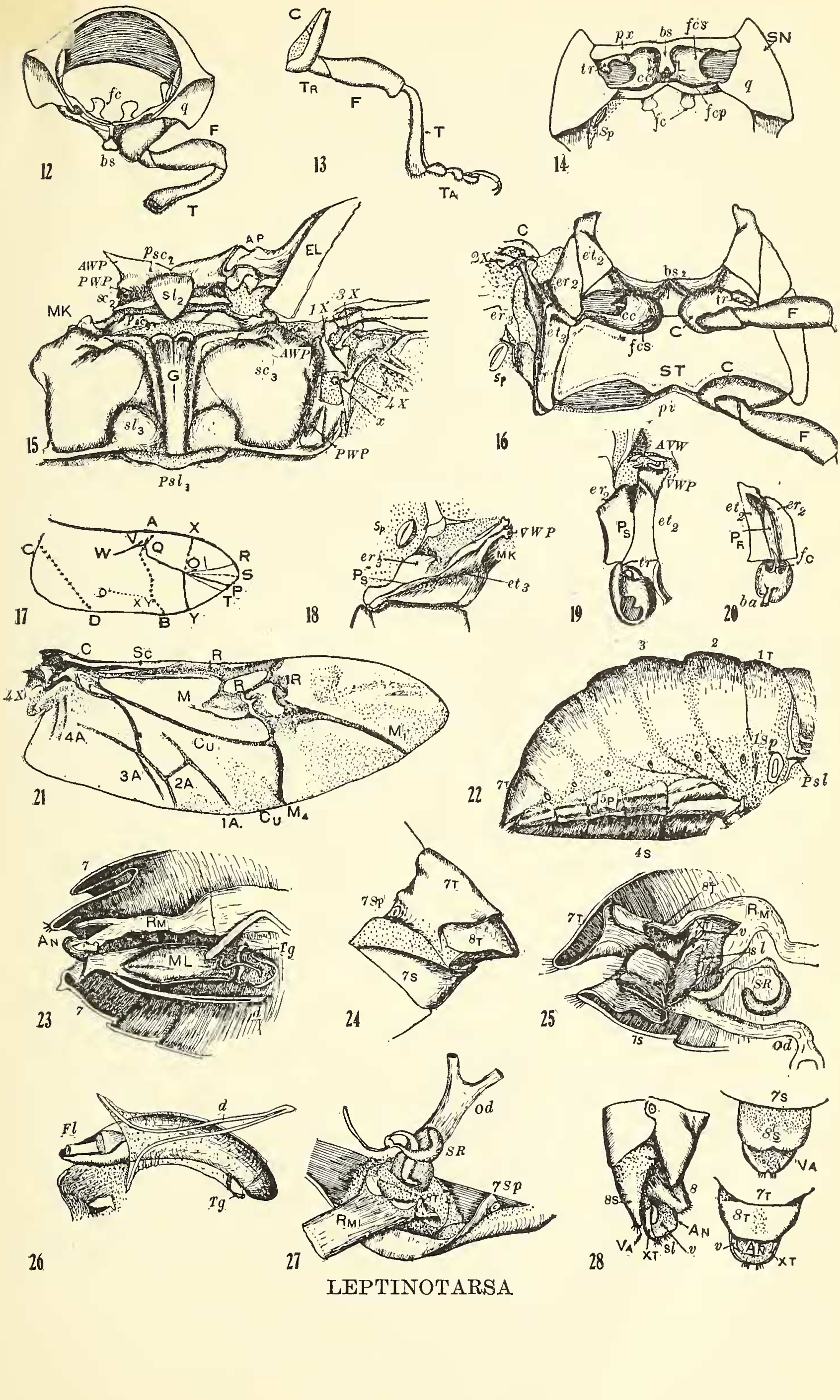
## PLATE VII

Figure 12. Prothorax (front view).
Figure 13. Fore leg.
Figure 14. Prosternum.
Figure 15. Meso- and Metanotum, showing attachment of fore and hind wings.
Figure 16. Meso- and Metasternum and respective pleural plates.
Figure 17. Outline of wing, showing method of folding.
Figure 18. Metapleuron.
Figure 19. Mesopleuron.
Figure 20. Mesopleuron, interior aspect, showing pleural ridge, furcum and sternal process.
Figure 21. Wing and its venation.
Figure 22. Side view of abdomen, showing spiracles, etc.
Figure 23. Tip of abdomen of ♂, interior parts, showing genitalia and alimentary canal.
Figure 24. Tip of abdomen of ♂, exterior aspect.
Figure 25. Tip of abdomen of ♀, showing genitalia and alimentary canal.
Figure 26. Genitalia of ♂, taken out of abdomen.
Figure 27. Genitalia of ♀, dorsal view, the rectum being pulled away.
Figure 28. Tip of abdomen of ♀, side, dorsal and ventral view.

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